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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with operation and maintenance of rotating biological surface (RBS) wastewater treatment systems. Included are objectives, instructor guides, student handouts and transparency masters. This is the first level of a three module series. The module considers purpose, functions, factors affecting process, process control and operation and maintenance of a RBS system. (Author/RH)

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BASIC ROTATING
BIOLOGICAL SURFACE OPERATION

Training Module 2.120.2.77

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USERS OF THE ERIC SYSTEM."

Prepared for the
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September, 1977

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INSTRUCTOR GUIDE
for
Training Module II2FWW
Basic Rotating Biological Surface

Module No:	Module Title:
II2FWW	Basic Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
9.0 hours	Topic:
	Summary
Objectives: Upon completion of this module, the participant will be able to	
1. Discuss the biology of the RBS unit and the primary wastewater parameters involved in process performance. 2. Describe an RBS unit, state how it functions and cite its purposes in an overall wastewater treatment plan. 3. Discuss RBS process control and the factors affecting the process in a plant. 4. Identify the primary maintenance requirements for the unit.	
Instructional Aids: Slides Transparencies Handouts	
Instructional Approach: Class Presentation and Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Reading assigned material in references. Study handout materials.	

Module No:	Module Title:
II2FWW	Basic Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
1.0 hours	Topic:
	Introduction: Wastewater Treatment Systems
Objectives: Upon completion of this topic, the participant will be able to 1. Describe typical wastewater treatment systems and unit processes. 2. Define secondary treatment criteria of USEPA and Iowa DEQ. 3. State the role of RBS units in wastewater treatment.	
Instructional Aids: Slides: Typical plant flow diagram. Sedimentation Transparency: Typical unit performance. Secondary treatment guidelines Tertiary treatment needs	
Instructional Approach: Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Read assigned material in references.	

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Module No: II2FWW	Topic: Introduction: Wastewater Treatment Systems
Instructor Notes:	Instructor Outline:
TRANS BD-1 Wastewater Treatment Systems TRANS BD-2 Sludge Treatment & Disposal <u>Note:</u> Ch.2 MOP#11 plus the appropriate individual process chapters. WPCF has a few slides of treatment units from its Course No. Two-1967 TRANS BD-3 Treatment Criteria <u>Note:</u> Assumed instructor is familiar with PL92-500 and Iowa Water Quality Criteria TRANS BD-4 Ammonia Nitrogen Concerns TRANS BD-5 Role of RBS Units <u>Note:</u> Autotrol publications cite many examples of installations	1. Discuss wastewater treatment systems and unit operations and processes a. Typical plant flow diagrams b. Cite purposes of units especially pre-lim-primary processes c. Cite typical water quality changes e.g. BOD & SS reductions d. Comment on tertiary treatment and sludge processes 2. Discuss treatment criteria, their basis and purposes a. U.S.EPA & P.L. 92-500 b. Iowa DEQ Water Quality Criteria 3. Note ammonia nitrogen concerns as its conversion to NO_3 is one of RBS's primary applications 4. Discuss the role of RBS units a. BOD reduction and organics b. Ammonia oxidation

Module No:	Module Title:
II2FWW	Basic Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
1.0 hours	Topic:
	Wastewater Chemistry; Sampling; Analysis
Objectives: Upon completion of this topic, the participant will be able to 1. List and describe significant water quality parameters including pH, alkalinity, the solids spectrum, TOC, COD, BOD, the nitrogen cycle and others. 2. Describe grab and composite sampling and discuss purposes and procedures of each approach. 3. Identify reference materials for use in conducting process control tests.	
Instructional Aids: Slides or Transparencies: Solids spectrum. Nitrogen cycle. Organic oxygen demand tests. Other tests	
Instructional Approach: Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Read assigned readings. Supplemental study as needed by participant. (Wastewater chemistry)	

Module No: II2FWW	Topic: Wastewater Chemistry; Sampling; Analysis
Instructor Notes:	Instructor Outline:
TRANS BD-6 Water Quality Parameters TRANS BD-7 Solids Spectrum TRANS BD-8 Organic Content of Wastewater TRANS BD-9 Variation in Flow & Strength TRANS BD-10 Nitrogen Cycle TRANS BD-11 Biochemical Oxygen Demand See Ch's 3 & 4 of MOP No.11	1. Discuss the meaning and significance of the water quality parameters likely associated with RBS plants. (Go lightly on details of analytical procedures) a. Note variations and potential impact with industrial additions b. Distinguish clearly between organic BOD and nitrogenous oxygen demand 2. Distinguish between grab and composite sampling. Cite examples of the need or benefit of each approach. 3. List and comment on laboratory procedural references a. Std. Methods b. WPCF MOP No18 c. EPA Manual d. Appendix III MOP No11

Module No: II2FWW	Module Title: Basic Rotating Biological Surface Operation
Approx. Time: 1.5 hours	Submodule Title: Topic: Fundamental Biological Systems
Objectives: Upon completion of this topic, the participant will be able to 1. Distinguish between and comment on aerobic, facultative, anaerobic and photosynthetic biological activity. 2. Discuss growth, synthesis and the end product aspects of aerobic bio-systems like RBS units. 3. Discuss the general nature of bio-activity in a fixed film system like the RBS or trickling filter process.	
Instructional Aids: Transparencies: Growth curves. Carbonaceous-heterotrophic activity. Nitrification. Population variations.	
Instructional Approach: Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Read assigned readings. Study handout materials.	

Module No: II2FWW	Topic: Fundamental Biological Systems
Instructor Notes:	Instructor Outline:
TRANS BD-12 Biological Terminology. TRANS BD-13 Biological Activity WPCF Publication No14 (Oper Training Course 2) has a color slide on trickling filter bio- action.	1. Discuss fundamental biological terminology Stress aerobic heterotrophs and autotrophs. Mention filamentous organisms. 2. Discuss biological growth. a. Note synthesis-excess sludge relation- ship in bio-treatment b. Cite meaning and significance of F/M ratio regarding type of bio-system 3. Discuss fixed film (attached growth bio-activity) a. Loss of bio-solids b. Transport of food and oxygen

Module No:	Module Title:
II2FWW	Basic Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
2.5 hours	Topic: RBS System: Purpose; components; functions; factors affecting process
Objectives: Upon completion of this topic, the participant will be able to 1. Sketch a typical RBS system and state its purpose or purposes in a wastewater treatment application. 2. Describe the component parts of an RBS unit and their function. 3. Discuss factors that affect process performance including pre-treatment for grit, grease and solids removal and process factors including pH, alkalinity, BOD, NH₃, temperature, etc.	
Instructional Aids: Slides and Transparencies: RBS System. RBS components. Existing plants. Temperature and pH effects.	
Instructional Approach: Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Read assigned material in references. Study handout materials.	

Module No: II2FWW	Topic: RBS System: Purpose; components; functions; factors affecting process
Instructor Notes:	Instructor Outline:
TRANS BD-14 Rotating Biological Surface Reactor TRANS BD-15 Typical RBS Configuration TRANS BD-16 Bio-Surf Plant Layout TRANS BD-17 Process Unit Components TRANS BD-18 Bio-module Units TRANS BD-19 Process Description Ch. 10. MOP No.11 Slides DS-1 through DS-17 Peawaukee, Wisc Emmetsburg, Iowa Austin, Minn Fulton, Ill. Spencer, Iowa	1. Describe the RBS system application a. BOD reduction b. Nitrification 2. Describe the component parts and how the RBS system functions 3. Discuss factors that affect process performance e.g. - grit accumulation in chambers - grease interference - solids clogging - pH depression - BOD/NH₃ ratio - cold temperatures - housing

Module No:	Module Title:
II2FWW	Basic Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
1.5 hours	Topic:
	RBS Process Control and Operation
Objectives: Upon completion of this topic, the participant will be able to 1. Identify the IDEQ process performance parameters and cite their significance. 2. Discuss the impact of pre-treatment on RBS performance. 3. Discuss some operational observational techniques to assess RBS unit performance e.g. appearance of bio-mass. 4. Comment on role and operation of final settling tank in RBS system performance.	
Instructional Aids: Handouts Transparency: Typical DEQ monthly report. Process parameters and their significance.	
Instructional Approach: Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1975 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Read assigned readings. Study handout materials.	

Module No: II2FWW	Topic: RBS Process Control and Operation
Instructor Notes:	Instructor Outline:
TRANS BD-20 IDeq Monthly Report TRANS BD-21 IDeq Effluent Monitoring Note: WPCF MOP No.11 and Autotrol data provide appropriate illustration Ask participants with RBS units in operation to share their experiences TRANS BD-9 Variations in Flow	1. Use Emmetsburg IDEQ monthly Report Form and Monitoring Requirements Sheet to illustrate and discuss monitoring of the RBS process. 2. Cite and discuss importance of pre-treatment regarding toxics, grit, grease, etc. 3. Discuss observational techniques e.g. DO change in stages Nitrate increases in stages Color of bio-mass 4. Discuss final settling tank operation a. Sludge pumping to avoid denitrification & rising sludge b. Sludge thickness and storage c. Overflow rates and affect of variable flow rates

Module No:	Module Title:
II2FWW	Basic Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
1.5 hours	Topic:
	Mechanical Units and Maintenance
Objectives: Upon completion of this topic, the participant will be able to 1. Describe the sources and types of maintenance instructions available for RBS units. 2. List most of the routine maintenance requirements for RBS units. 3. List areas to watch for potential problems.	
Instructional Aids: Handouts Transparencies: Maintenance Schedule. Unit cross sections. Typical maintenance manual instructions.	
Instructional Approach: Discussion	
References: 1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976 2. Autotrol Corporation, Bio-surf Design Manual, 1972 3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process	
Class Assignments: Read assigned readings. Study handouts from operating manuals.	

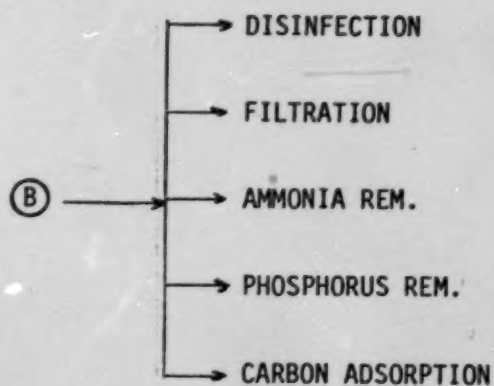
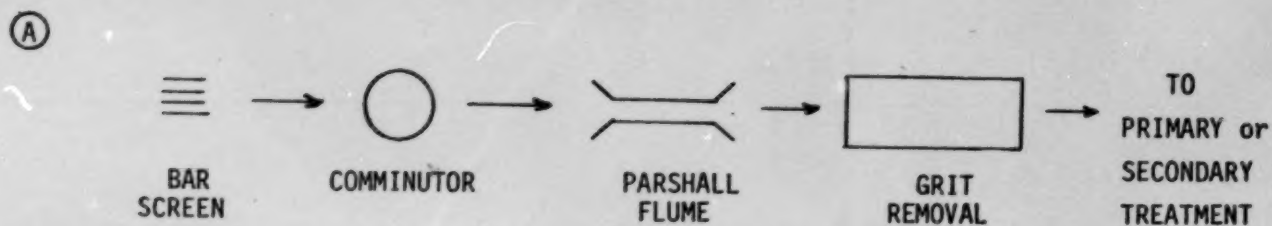
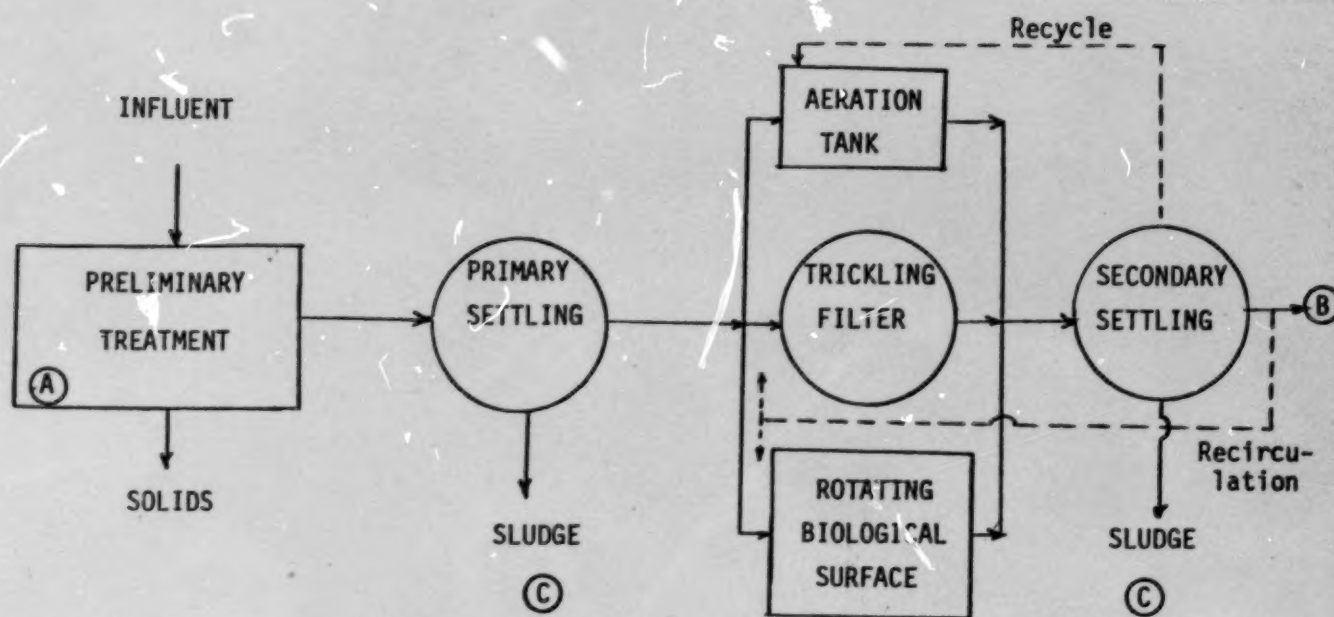
Module No: II2FWW	Topic: Mechanical Units and Maintenance
Instructor Notes:	Instructor Outline:
TRANS BD-22 Preventive Maintenance Guide TRANS BD-23 Lubrication & Maintenance TRANS BD-24 Typical Maintenance -Autotrol - TRANS BD-25 Typical Troubleshooting=Autotrol	1. List and comment on Autotrol and WPCF publications on maintenance, safety, records etc. (Include other manufacturers when materials becomes availbe) 2. Cite the routine maintenance requirements 3. Note typical problem areas and remedies 4. Ask participants with operating plants to share their experiences.

Module No: II2FWW, II3JWW, II4OMW	Topic: References Utilized in Developing Training Module Material
Instructor Notes:	Instructor Outline:
	Water Pollution Control Federation, <u>Operation Wastewater Treatment Plants</u>, MOP No.11, 1976 Autotrol Corporation, <u>Bio-surf Design Manual</u>, 1972 Autotrol Corporation, <u>Operating and Maintenance Manual for the Bio-surf Waste Treatment Process</u> Autotrol Corp., "Bio-surf Process Package Plants for Secondary Wastewater Treatment", 975-1.1.2, 1975 Autotrol Corp., "The Bio-surf Process", (G-3-876), 1976 U.S.E.P.A., "Process Design Manual for Nitrogen Control", October 1975 Metcalf & Eddy, Inc. <u>Wastewater Engineering</u>, McGraw-Hill, 1972 Clark, J.W., Viessman, W. Jr and Hammer, M., <u>Water Supply and Pollution Control</u>, IEP, 1977 Sawyer, C.N. & McCarty, P.L., <u>Chemistry for Sanitary Engineers</u>, McGraw-Hill 1967 ADHA, <u>Standard Methods for the Examination of Water and Wastewater</u>, 14th Edit. 1975 SPCF, <u>Simplified Laboratory Procedures for Wastewater Examination</u>, MOP No. 18, 1970 U.S.E.P.A., <u>Methods for Chemical Analysis of Water and Wastes</u>, 1974 Mather, Stanley E.J. "Plant Upgraded With Rotating Biological Surface System", <u>Public Works</u>, Jan. 1977 Congram, G.E., "Biodisk Improves Effluent-Water-Treating Operation", <u>Oil & Gas Journal</u>, Feb. 1976

Module No: II2FMW, II3JMW, II4OWW	Topic: References Utilized in Developing Training Module Material
Instructor Notes:	Instructor Outline:
	Wexler, H.M., "Value Engineering: Make Sure The Costs Are Right", <u>Water & Wastes</u> <u>Engr</u>, June 1976 Antonie, R.L. "BOD Removal and Nitrification with the Rotating Biological Contactor," Great Plains Design Conference, March 1977 Malhotra, S.K., Williams, T.C. & Morley, W.L., "Performance of a Bio-disk Plant in a Northern Michinga Community", WPCF Conf., 1975

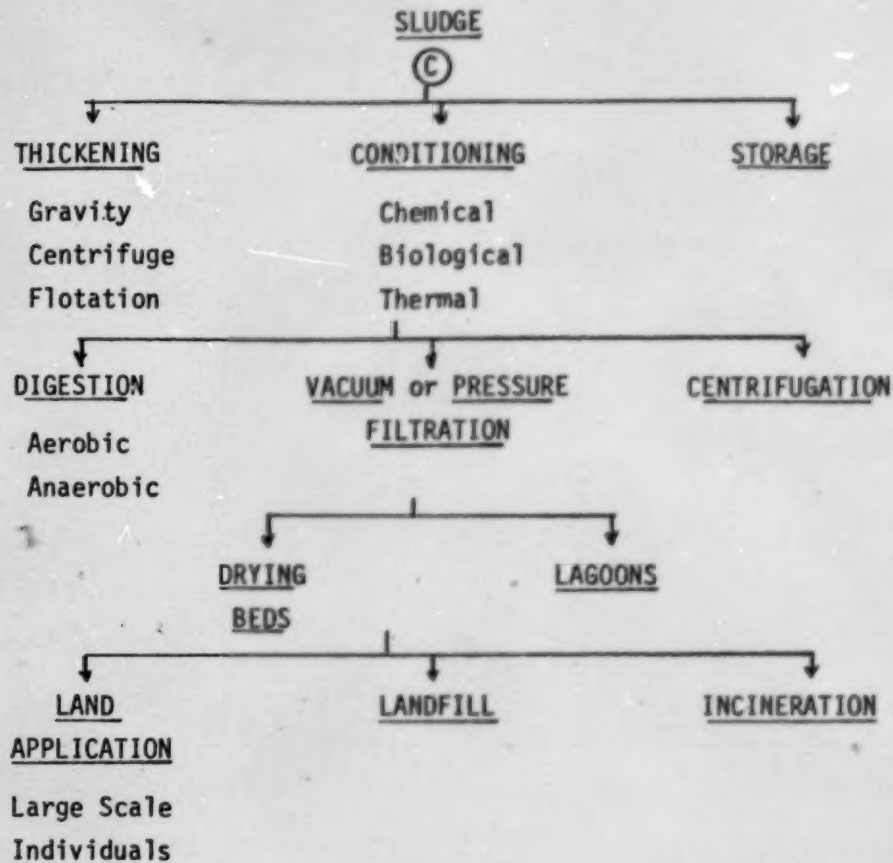
TRANSPARENCIES
for
Training Module II2FWM
Basic Rotating Biological Surface

WASTEWATER TREATMENT SYSTEMS



ADVANCED or TERTIARY
TREATMENT

SLUDGE TREATMENT & DISPOSAL



TRANS BD-2

TREATMENT CRITERIA

U.S. Environmental Protection Agency - Secondary Treatment

	Monthly Ave.*	Weekly Ave.*
BOD ₅	30 mg/l	45 mg/l
SUSP. SOLIDS	30	45
FECAL COLIFORM	200/100 ml	400/100 ml
pH	6.0 to 9.0	

*Maximum Values - Note: 85% Removal is Minimum Requirement

Iowa Department of Environmental Quality

Additional and/or more stringent criteria may be required in order to protect the receiving stream water quality. Designated uses include aquatic life, body contact recreation and drinking water supply.

e.g. A plant on a very small stream may have to meet

BOD₅ - 10 mg/l SUSP. SOLIDS - 20 mg/l

NH₃ - N - 2 mg/l and FECAL COLI. - 200/100 ml

TRANS BD-3

AMMONIA NITROGEN-WATER QUALITY CONCERNS

- OXYGEN DEMAND - $\text{NH}_3\text{-N}$ will require approximately 4.6 mg/l per 1 mg/l NH_3 as N to oxidize to nitrates. Can occur in receiving streams and affect the oxygen balance
- TOXICITY - $\text{NH}_3\text{-N}$ is considered to be toxic to aquatic life. Iowa has approved a maximum concentration of 2.0 mg/l as N as a stream limitation. Water pH is a significant factor
- REACTION with CHLORINE - Chloramines e.g. NH_2Cl may be formed in disinfection. Chloramines can be toxic to aquatic life
- Additional chlorine requirement to obtain disinfection levels
- NUTRIENT - Is an essential nutrient in growth of bacteria and aquatic life

ROLE of RBS UNITS

SECONDARY TREATMENT

Reduction of BOD by aerobic biological treatment
Used in place of a rock trickling filter or an
activated sludge process
Applied to municipal and to industrial wastewater
Oxidize some organics in industrial wastes

TERTIARY TREATMENT

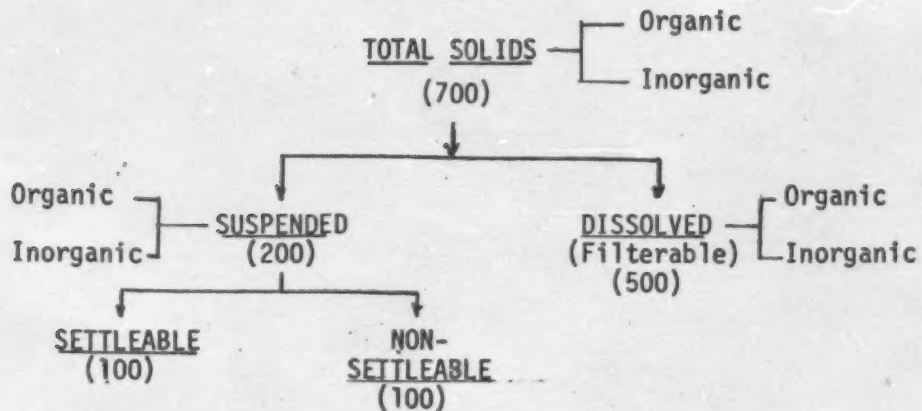
Decrease ammonia nitrogen ($\text{NH}_3\text{-N}$) concentration by
biological oxidation
Used alone or in combination with other biological
processes

WATER QUALITY PARAMETERS

- pH - A measure of the hydrogen ion concentration

$$\text{pH} = \log \frac{1}{[\text{H}^+]} \quad \text{pH} + \text{pOH} = 14$$
- TEMPERATURE - $^{\circ}\text{F} = 9/5 \text{ }^{\circ}\text{C} + 32$
- ALKALINITY - Due to presence of hydroxides, carbonates and bicarbonates of calcium, magnesium, sodium, potassium and ammonia
- NITROGEN - Typical in domestic wastewater:
- | | |
|---|----------------|
| Total Nitrogen | 20 to 85 mg/l |
| Organic Nitrogen | 8 to 35 |
| Ammonia Nitrogen, NH_3 | 12 to 50 |
| Nitrite & Nitrate
(NO_2) (NO_3) | Generally zero |
- PHOSPHORUS - Essential nutrient in biological treatment
- GREASE - Cause clogging; interfere with biological life
- TOXICS - e.g. Heavy metals, cyanide. Interfere with bio-activity
- DISSOLVED OXYGEN - Oxygen in solution. Winkler titration.
 DO Probes. Needed for aerobic bio-activity.

SOLIDS SPECTRUM



VOLATILE — Essentially organic fraction - 600°C

FIXED — Essentially inorganic fraction

SETTLEABLE — One hour - Imhoff cone

GRIT — Inorganics. Higher settling rate

CARRIAGE WATER

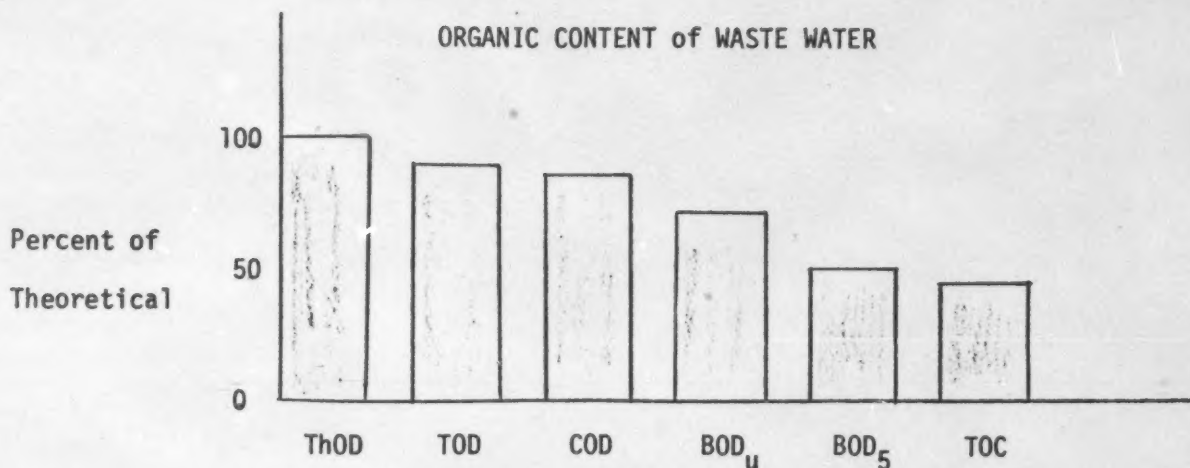
SOLIDS — Dissolved solids in water supply

PARTICLE SIZE — Settleable - greater than 10 microns

Colloidal - 10^{-3} to 1 micron

1 micron approx. equals 1/25000 "

Bacterial Diameter ~ 1 micron



ThOD - If chemical formula of organics is known
ThOD may be computed. (Theoretical Oxygen Demand)

TOD - Convert organics to stable end products in a platinum-catalyzed combustion chamber (Total Oxygen Demand)

COD - Oxidize organics chemically in an acidic medium. (Chemical Oxygen Demand)

BOD_u - The organics are oxidized biologically in the presence of oxygen and adequate nutrients at 20°C. (The Ultimate (20 day) Biochemical Oxygen Demand)

BOD₅ - The 5 day Biochemical Oxygen Demand

TOC - Organic carbon is oxidized to carbon dioxide in a high temperature furnace in the presence of a catalyst. (Total Organic Carbon)

Typical Domestic Wastewater: BOD/COD 0.4 to 0.8

BOD/TOC 0.8 to 1.0

VARIATION IN FLOW AND STRENGTH

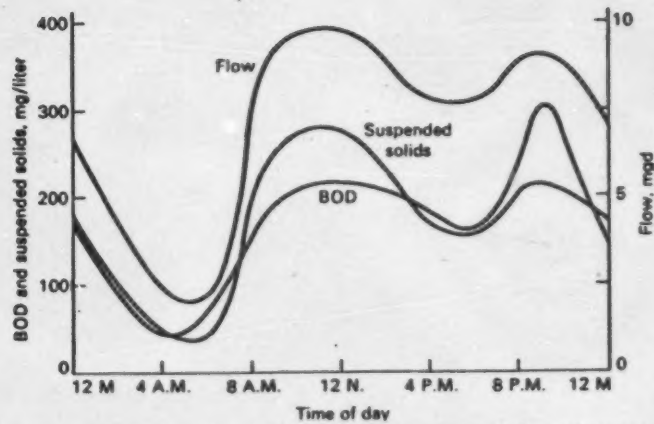
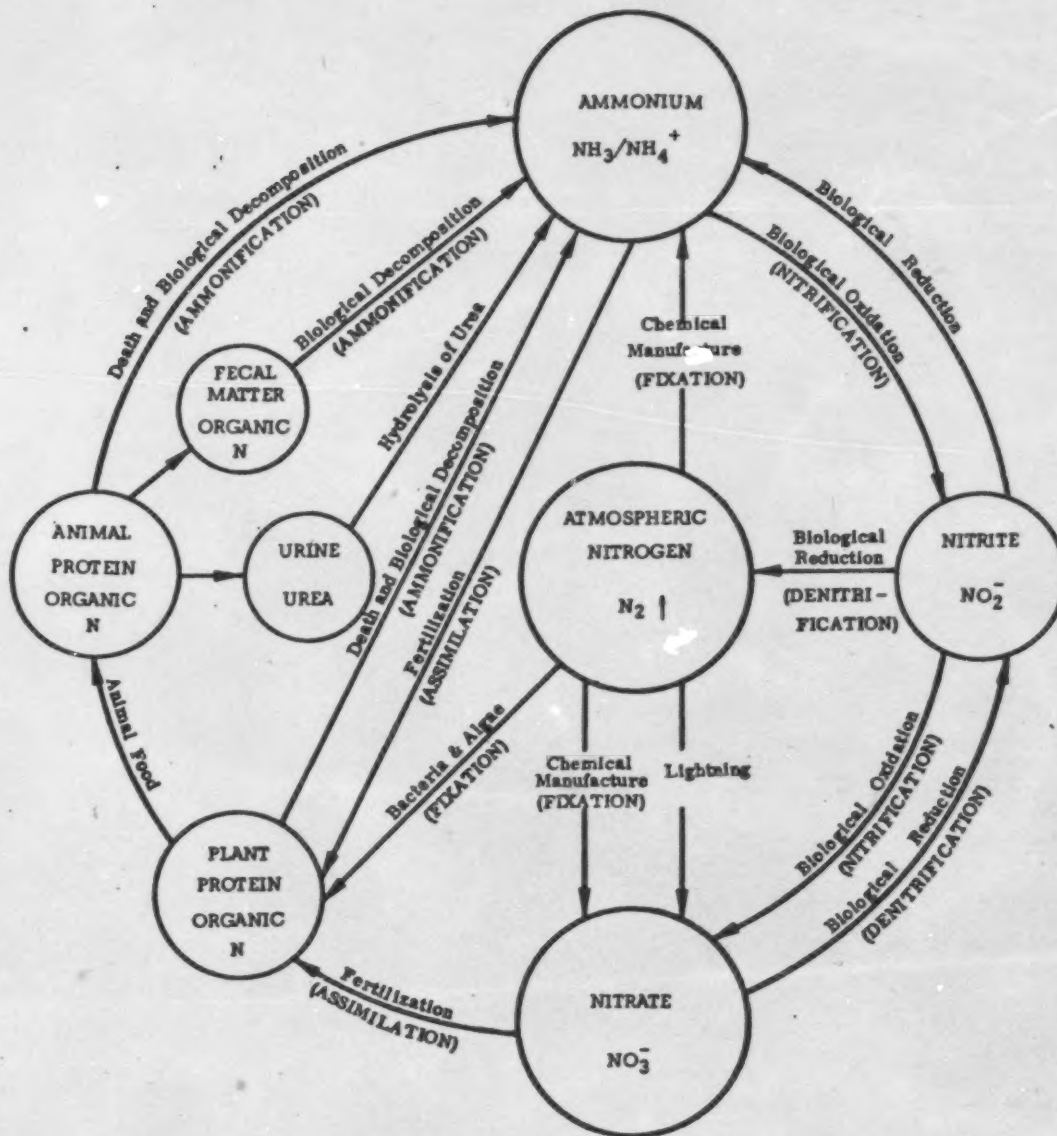
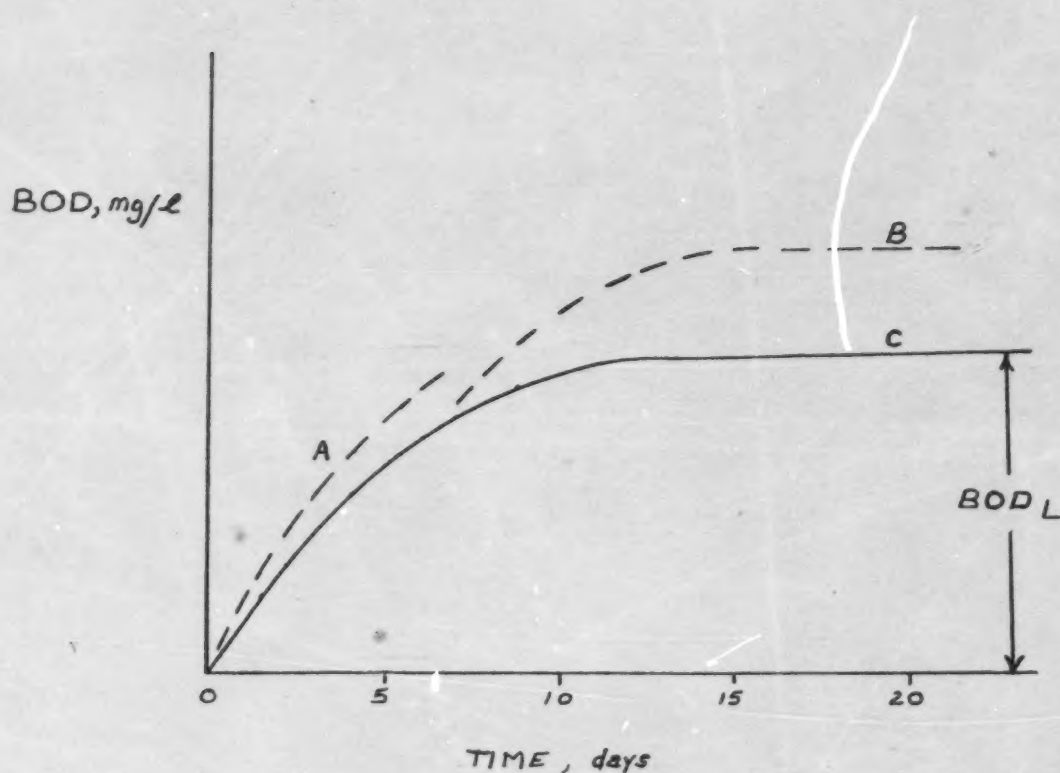


FIG. 7-1 Typical hourly variation in flow and strength of domestic sewage.

NITROGEN CYCLE



BIOCHEMICAL OXYGEN DEMAND



Curve C represents the carbonaceous oxygen demand

$$Y_5 = L (1 - 10^{-5k}) \quad Y_5 - \text{BOD at 5 days}$$

$L - \text{BOD}_L$

$k - \text{Deoxygenation rate}$

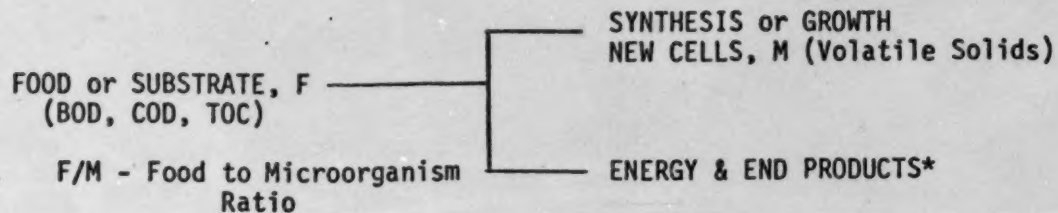
Curve B illustrates normal progression of nitrification
(At 20°C, it takes from 6 to 10 days to develop
a nitrifying population)

Curve A illustrates nitrification initially due to an adequate
population of nitrifiers in the sample e.g. RBC effluent

Note: Nitrification effects can be separated out by pretreating
the sample e.g. pasteurization or by the use of chemical
inhibitory agents e.g. thiourea

TRANS BD-11

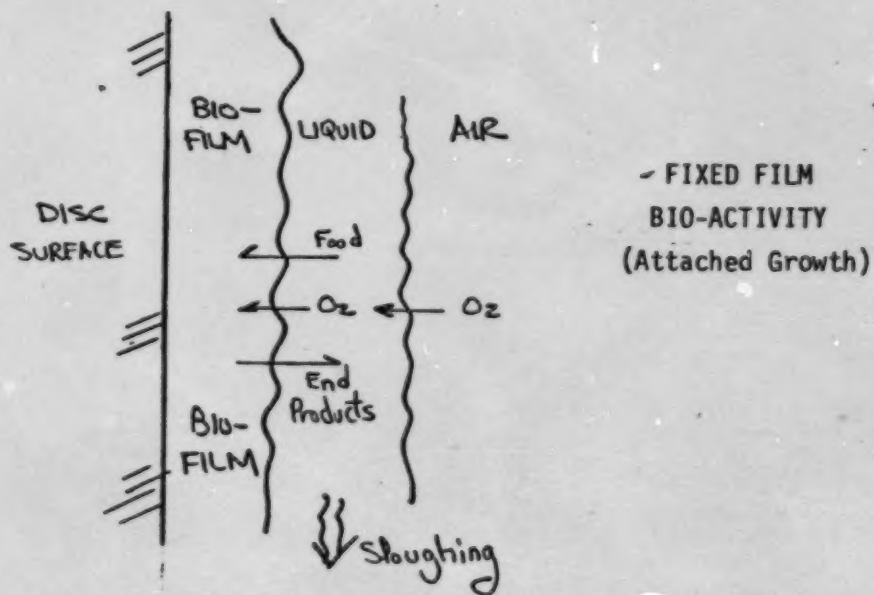
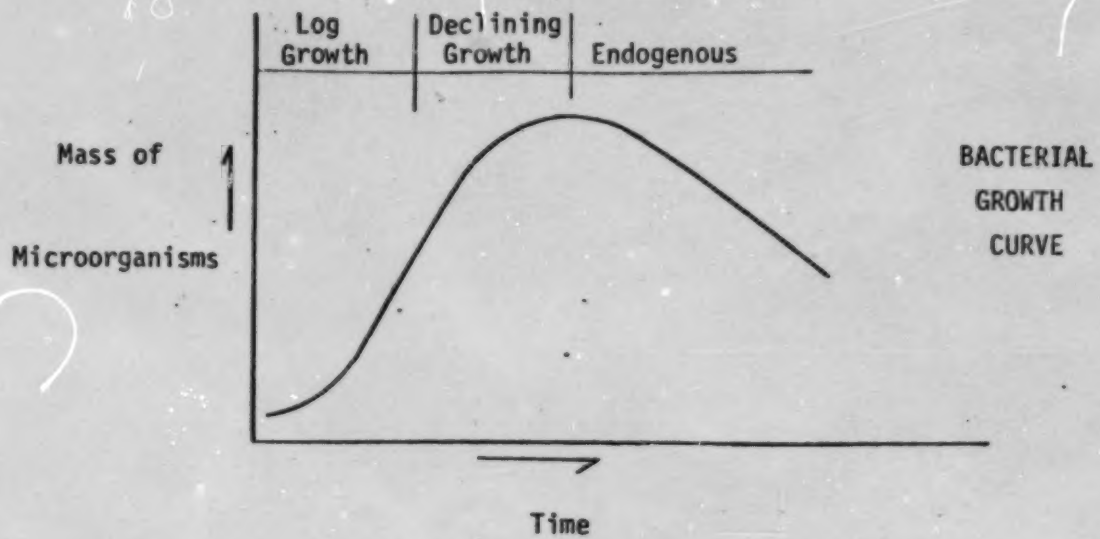
BIOLOGICAL TERMINOLOGY

* ORGANIC - HETEROTROPHSAEROBIC (Presence of D.O.) -- $\text{CO}_2 + \text{H}_2\text{O}$ ANAEROBIC (Absence of D.O.) -- $\text{CH}_4 + \text{CO}_2$

FACULTATIVE -- Can adjust to presence or absence of D.O.

* INORGANIC - AUTOTROPHSNITRIFICATION -- $\text{NH}_3 \rightarrow \text{NO}_2 \rightarrow \text{NO}_3$ (Aerobic) (Uses CO_2 as carbon source)

PHOTOSYNTHESIS -- Uses CO_2 as carbon source
 Yields oxygen in presence of light
 e.g. algae



TRANS 80-13

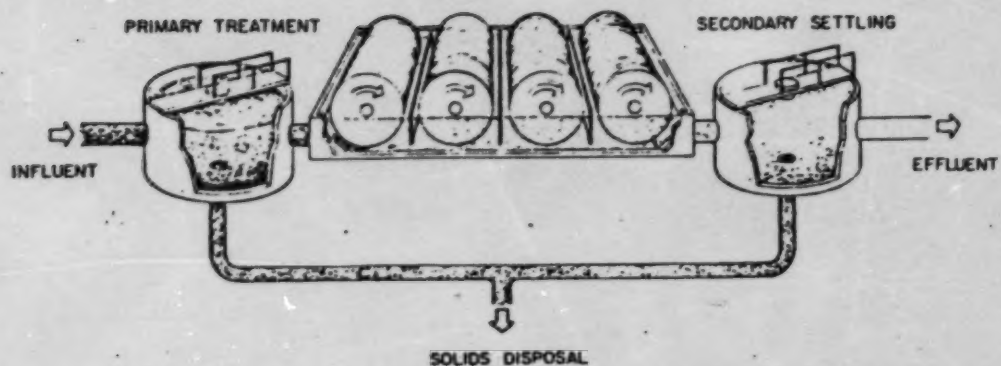


FIGURE 10-5. Rotating biological reactors should be preceded by pretreatment and followed by secondary sedimentation.

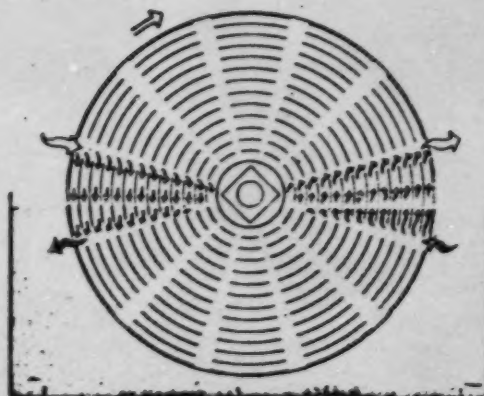
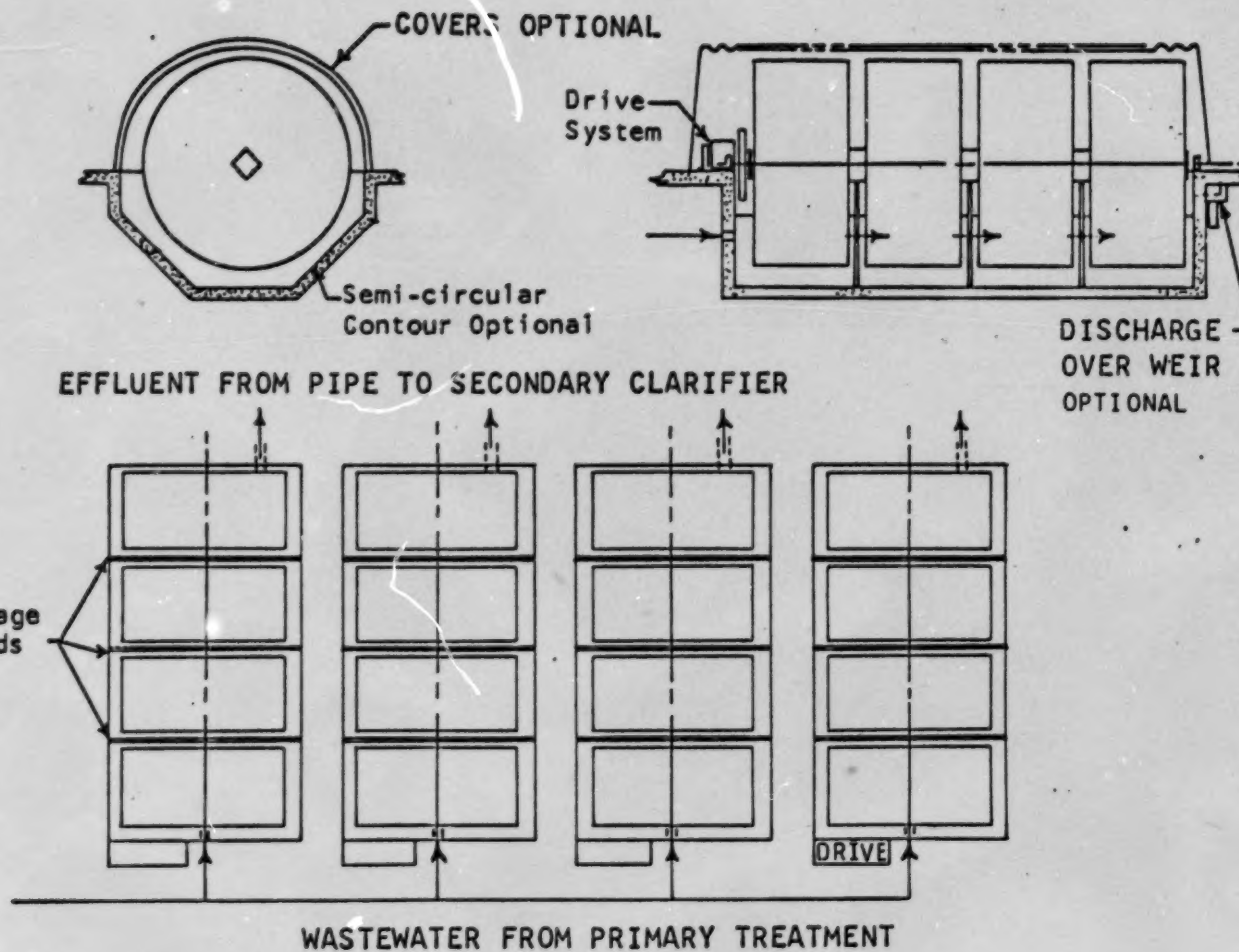


FIGURE 10-4. Reactor carries film of wastewater into the air. Wastewater trickles down the surface and absorbs oxygen from the air.

TYPICAL RBS CONFIGURATION



TRANS BD-15

 Autotrol CORPORATION BIO-SYSTEMS DIVISION	
Figure E-1	Dwg. No. A-0025
CONFIGURATION NO. 1 FOUR-STAGE BIO-SURF SHAFTS IN PARALLEL	

BIO-SURF PLANT LAYOUT

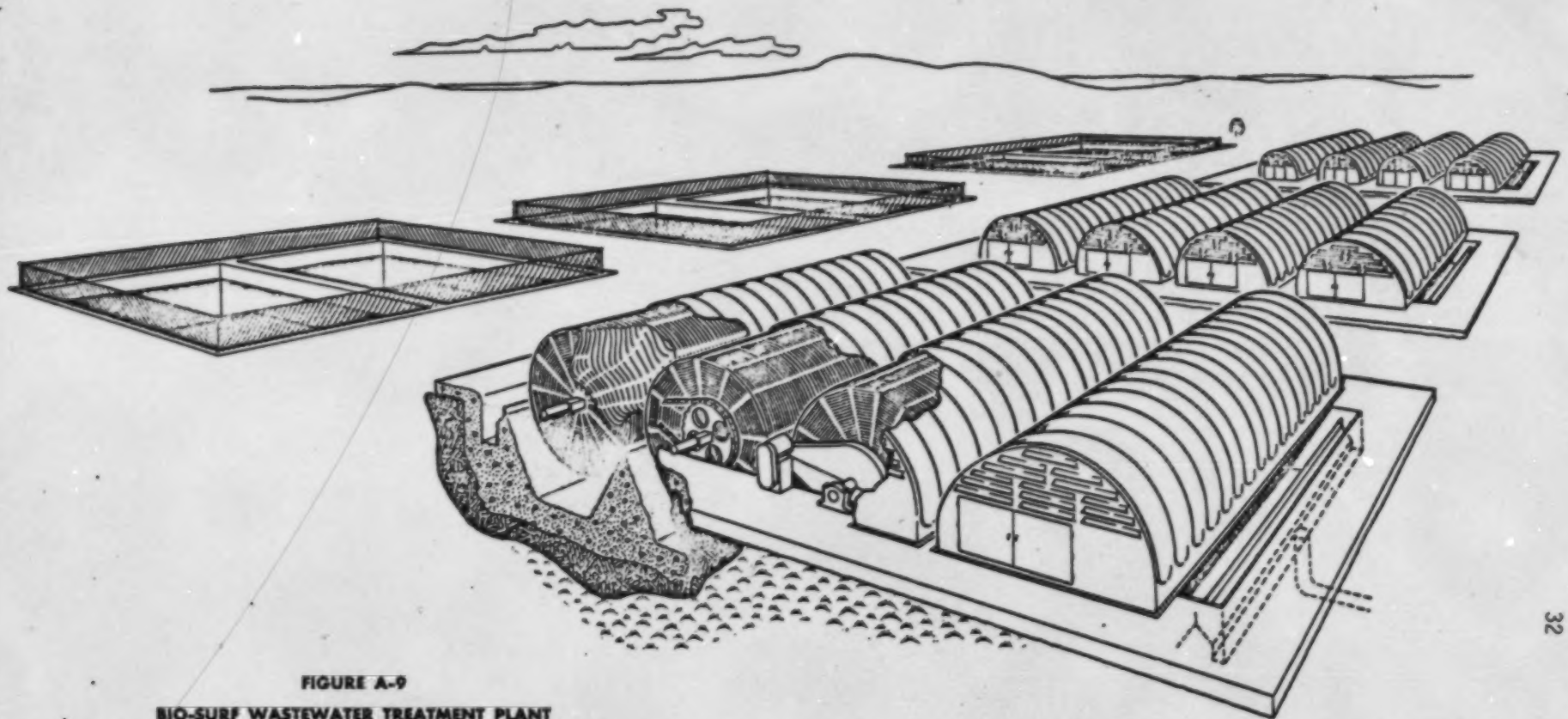
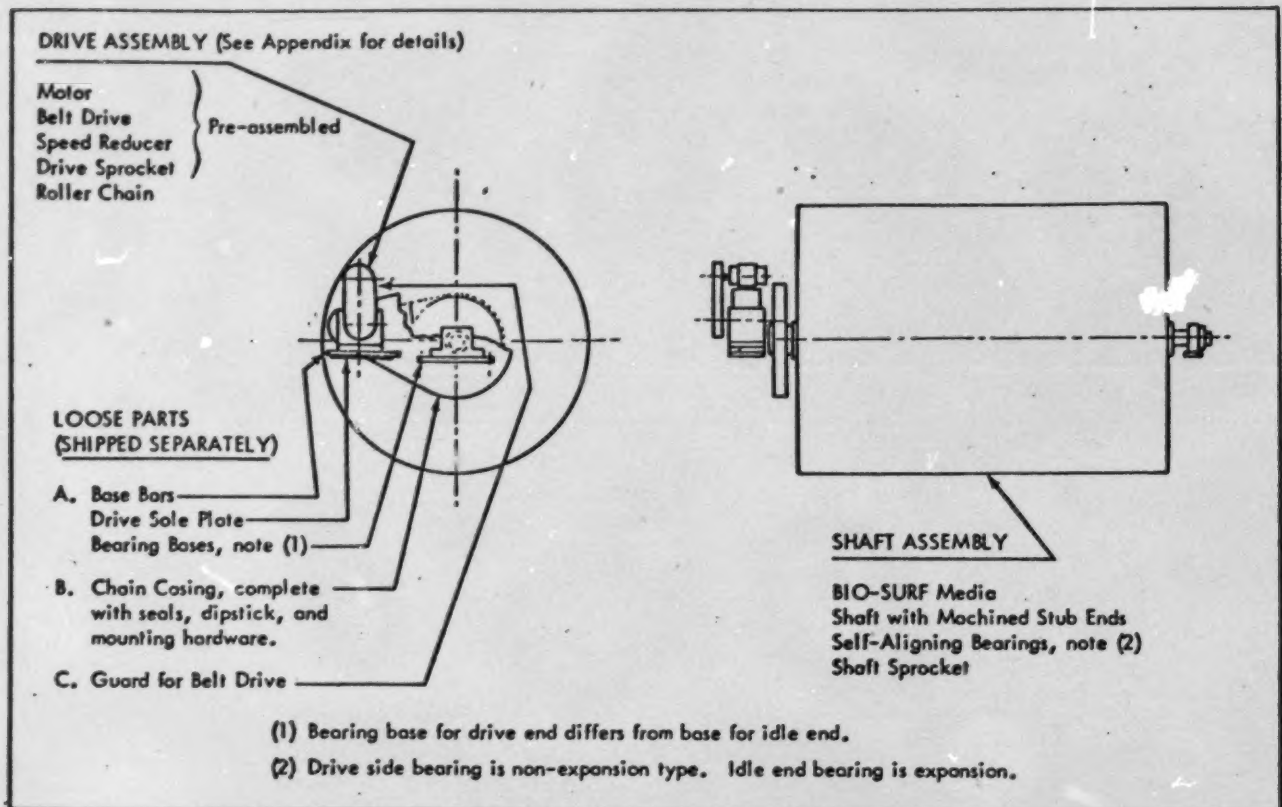


FIGURE A-9
BIO-SURF WASTEWATER TREATMENT PLANT

TRANS BD-16



BIO-SURF Media

The photo shows a cross-section of the BIO-SURF media. It consists of alternating flat and corrugated sheets of polyethylene which are thermally bonded for strength and long service life. The corrugated sheets are vacuum-formed with integral radial passages. The radial passages allow a free flow of wastewater, air and stripped biomass in and out of the media as it rotates.



BIO-MODULE UNITS

Description

A BIO-MODULE unit is a packaged wastewater treatment plant designed to treat domestic or industrial sewage through a process where fixed aerobic cultures of microorganisms remove both dissolved and suspended organic matter from the wastewater. A BIO-MODULE unit consists of a wet well, rotating bucket feed mechanism, and multi-stage BIO-SURF media incorporated into a semi-circular steel tank. The BIO-MODULE unit is intended to operate in conjunction with primary treatment, secondary clarifier and sludge disposal facilities.

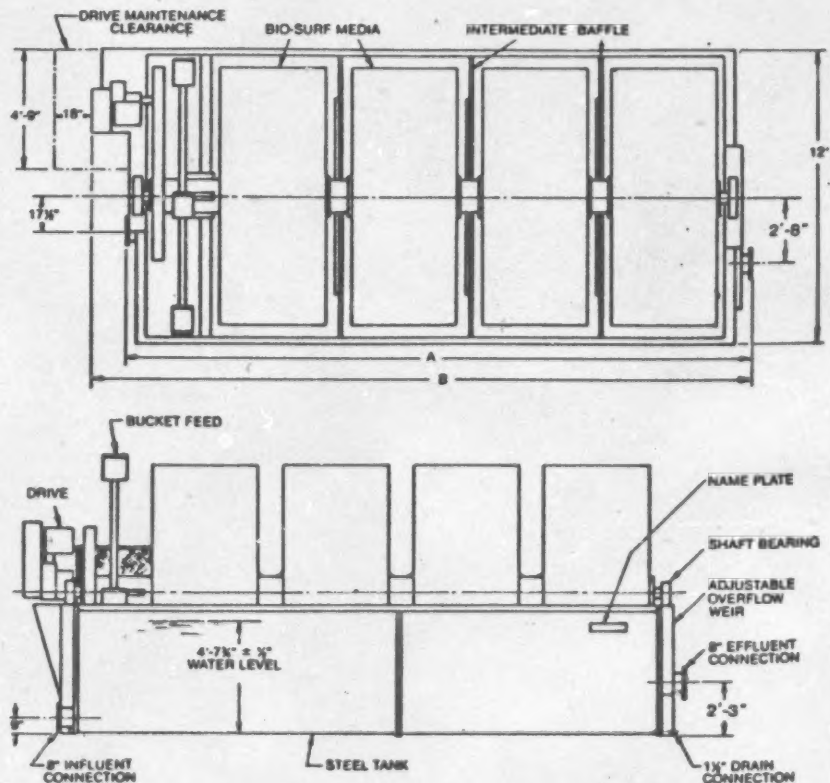
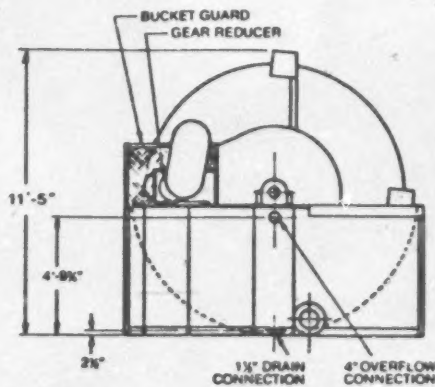
Operation

After pretreatment, wastewater enters the BIO-MODULE wet well where it is picked up by the rotating buckets. The buckets are attached to the main shaft by hollow arms. As the bucket is raised to the same elevation as the shaft, the wastewater flows down the hollow arm and is discharged parallel to the shaft over a bulkhead into the first stage of the BIO-SURF process treatment.

After entering the first stage of the BIO-SURF process, wastewater passes through a submerged orifice in the center of each bulkhead separating individual stages of treatment. Mixed liquor from the last stage of media passes over a weir and flows to a secondary clarifier.

BIO-MODULE		3.2m		
MODEL NO.	621-104	621-154	621-204	
Effective media area (ft ²)	23,000	39,500	56,000	
Operating wt. (lb.)	53,000	73,000	94,000	
Shipping wt. (lb.)	16,000	20,000	24,000	
Motor horsepower*	1½	2	3	
A	15'-3½"	20'-3½"	25'-3½"	
B	16'-6½"	21'-6½"	26'-6½"	
Bucket pump capacities with 1, 2, 3 or 4 buckets (GPD)	22,500	45,000	67,500	90,000

* 230/460V three phase open drip proof enclosure
Other options available



The BIO-SURF process is a secondary biological treatment system. It consists of from 2 meter to 12-foot diameter corrugated polyethylene media, which is mounted on a horizontal shaft up to 20 feet long and placed in a steel or concrete tank. The media is rotated at 1.5-3 rpm while about 40% of the surface area is immersed in wastewater.

Shortly after start-up, microorganisms begin to grow on the surface of the media. One to two weeks later, the entire surface area is covered with a 2-4 mm thickness of biomass.

Rotation of the media alternately contacts the biomass with the wastewater for removal of organic materials and exposes it to the air for absorption of oxygen. The amount of attached biomass is relatively large compared to the amount of wastewater under treatment -- the equivalent of 10,000 to 20,000 mg/l of mixed liquor volatile solids. This allows high degrees of treatment to be achieved for relatively short retention times -- usually about one hour for most treatment requirements.

Rotation of the media at a peripheral velocity of 1.0 foot per second exerts shearing forces on the biomass which strips excess biological growth and prevents clogging. The mixing action of the media keeps stripped biological solids in suspension until the flow of treated wastewater carries them to a clarifier for separation and disposal.

Excerpts from Autotrol Publications

- Power Requirements - 0.3 hp-hr per pound BOD removed
- Effluent Quality - Some applications can achieve effluents of less than 10 mg/l BOD and suspended solids and less than 1 mg/l of ammonia nitrogen
- Settling - Solids settling rate 10 to 15 ft/hour
Low solids loadings. Can achieve 3 to 4% sludge solids
- Modules - Can be of modular construction to aid expansion

* From Autotrol Corporation publications

OPERATION PERMIT SYSTEM MONTHLY MONITORING REPORT

FACILITY NAME EMMETTSBURG
FACILITY NUMBER _____
DISCHARGE SERIAL NUMBER _____

MONTH _____ YEAR _____

DATE	PRECIPITATION INCHES/DAY	GENERAL				RAW SLUDGE		BOD (5 DAY 20° C)					SUSPENDED SOLIDS					SETTLEABLE SOLIDS ML/L				AMMONIA NITROGEN			pH		EFFLUENT DISSOLVED OXYGEN MG/L	EFFLUENT FECAL COLIFORM NO./100ml	EFFLUENT RESIDUAL CHLORINE MG/L	RECEIVING STREAM FLOW-CFS
		RAW SEWAGE TEMPERATURE	TOTAL FLOW 1,000'S GPD	BY-PASSED 1,000'S GPD	RECIRCULATION 1,000'S GPD	GALLONS PUMPED 100'S GPD	TOTAL SOLIDS %	VOLATILE SOLIDS %	INFLUENT MG/L	INFLUENT LBS/DAY	PRIMARY EFFLUENT MG/L	R.B.S. EFFLUENT MG/L	FINAL EFFLUENT MG/L	FINAL EFFLUENT LBS/DAY	INFLUENT MG/L	INFLUENT LBS/DAY	PRIMARY EFFLUENT MG/L	R.B.S. EFFLUENT MG/L	FINAL EFFLUENT MG/L	FINAL EFFLUENT LBS/DAY	INFLUENT MG/L	INFLUENT LBS/DAY	FINAL EFFLUENT MG/L	FINAL EFFLUENT LBS/DAY	INFLUENT	FINAL				
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TOTAL																														
AVG.																														
MAX.																														
MIN.																														

INFLUENT 24 HOUR SAMPLE COLLECTION (000)

BOD₅ _____ MG/L _____ LBS/DAY(5)(76024)
SUSPENDED SOLIDS _____ MG/L _____ LBS/DAY(5)(74024)
AMMONIA NITROGEN _____ MG/L _____ LBS/DAY(5)(70424)
FLOW _____ MILLION GALLONS/DAY(74324)

EFFLUENT 24 HOUR SAMPLE COLLECTION (001)

BOD₅ _____ MG/L _____ LBS/DAY(5)(76024)
SUSPENDED SOLIDS _____ MG/L _____ LBS/DAY(5)(74024)
AMMONIA NITROGEN _____ MG/L _____ LBS/DAY(5)(70424)
FECAL COLIFORM _____ ORGANISMS/100 ML (76324)

SIGNATURE OF EXECUTIVE _____

TITLE _____

ROTATING BIOLOGICAL

TRANS BD-20

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3. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

- (a) During the period beginning on the date of issuance and lasting through June 30, 1981 the permittee is authorized to discharge from outfall serial number 001.

Such discharge shall be limited and monitored by the permittee as specified:

Wastewater Parameter	Effluent Limitations				Monitoring Requirements		
	kg/day (lbs/day)		Other Units (Specify)		Measurement Frequency	Sample Type	Sample Location
	Daily Avg	Max	Daily Avg	Max			
Flow m ³ /day (MGD)	-	-	2082(0.55)	3123(.825)	Daily	-	1 or 2
BOD (5-day)**	21(46)	31(69)	10 mg/l	15 mg/l	1/month	24-hr. Composite	1,2
Suspended Solids**	42(92)	62(138)	20 mg/l	30 mg/l	1/month	24-hr. Composite	1,2
Ammonia Nitrogen (as N)**	4(9)	10(23)	2 mg/l	5 mg/l	1/month	24-hr. Composite	1,2
Fecal Coliform**	-	-	-	-	1/ 3 months	Grab	2
BOD (5-day)	-	-	-	-	2/week	6-hr. Composite	1,2,3
Ammonia Nitrogen (as N)	-	-	-	-	2/week	6-hr. Composite	1,2,3
Settleable Solids	-	-	-	-	3/week	Grab	1,2,3
pH	-	-	From 6.5 to 9.0		3/week	Grab	1,2
Dissolved Oxygen	-	-	-	-	3/week	Grab	2
Temperature	-	-	-	-	3/week	Grab	1,3
Residual Chlorine @	-	-	-	-	3/week	Grab	2
EQAP***	-	-	-	-	Monthly	Grab	2

@Disinfection shall be practiced from April 1 through October 31 and the monitoring performed as specified.

There shall be no discharge of floating or settleable substances in other than trace amounts.

*Samples collected as specified in the monitoring requirements shall be taken at the following location(s):

- 1 - raw wastewater influent to the treatment facility
- 2 - final effluent from the treatment facility
- 3 - effluent from final clarifier

**These analytical values shall be recorded in the special spaces provided on the Records of Operation report form.

***Sample submitted for the Effluent Quality Analysis Program (EQAP) conducted in accordance with Chapter 18 of the Rules of the Iowa Department of Environmental Quality (1975 Iowa Administrative Code).

PREVENTIVE MAINTENANCE GUIDE - WPCF MOP 11

TABLE 10-1. Preventive Maintenance Guide

Procedure	Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
Check contactor shaft bearings. Feel to see if they are running hot. Listen for unusual noises. This includes any pillow block on output of speed reducer.	X				
Feel motors to see if they are running hotter than design temperature. Check area around the drive train and shaft bearings for oil spills.	X				
Check oil levels in speed reducer and chain drive system.	X				
Lubricate contactor shaft bearings. Consult manufacturer's instructions.		X			
Check chain drives for alignment and tightness.			X		
Check belt drives (if any) for alignment and tightness.			X		
Coat machined ends of contactor shaft with grease in case these ends do not have permanent coating.			X		
Adjust contactor shaft bearings. This includes any pillow block on the reducer output.			X		
Change lubricant for chain drive system. Change oil in speed reducer. Clean magnetic drain plug, if any.				X	
Replace the grease in the seals (if any) in the speed reducer. Consult manufacturer's instructions.					X
Grease bearings in the electric motor (if applicable). Consult manufacturer's instructions.					X

LUBRICATION & MAINTENANCE - AUTOTROL

LUBRICATION AND PREVENTATIVE MAINTENANCE CHART

PROCEDURE	INTERVAL					
	Daily	Weekly	4 wk.	3 mo.	6 mo.	12 mo.
1. Check for hot mainshaft and drive package output bearing (3 HP drive only). If too hot for hand, use pyrometer. Replace bearings if temperature exceeds 200°F.	X					
2. Check for unusual noises in mainshaft and reducer output bearings.	X					
3. Grease the mainshaft bearings and drive package output bearing (3 HP drive only). See Table 3, Recommended Lubricants, for proper lubricants. Add grease slowly while shaft rotates. When grease begins to come out of seals, the bearings contain the correct amount of grease. Add six full strokes where bearings cannot be seen.		X				
4. Inspect all chain drives, see MAINTENANCE INSTRUCTIONS.			X			
5. Inspect mainshaft bearings and drive package output bearing (3 HP drive only). See MAINTENANCE INSTRUCTIONS.			X			
6. Apply a generous coating of general purpose grease to mainshaft stub ends, mainshaft bearings and end collars.			X			
7. Change oil in chain casing. See Table 3, Recommended Lubricants. Be sure oil level is at or above the mark on the dipstick.				X		
8. Inspect belt drive (drive package), see MAINTENANCE INSTRUCTIONS.				X		
9. Change oil in speed reducer. See Table 3, Recommended Lubricants for correct oil.					X	
10. Clean magnetic drain plug in speed reducer.					X	
11. Purge the grease in the double-sealed shaft seals of the speed reducer by removing the plug located 180 degrees from the grease fitting on both the input and output seal cages, pump grease into the seal cages and replace plug. See Table 3, Recommended Lubricants for proper grease.					X	
12. Grease motor bearings, see Table 3, Recommended Lubricants, and OPERATING INSTRUCTIONS, U.S. ELECTRICAL MOTORS (in appendix). To grease motor bearings, stop motor and remove drain plugs. Inject new grease with pressure gun until all old grease has been forced out of the bearing through the grease drain. Run motor for approximately five minutes to relieve bearing of excess grease. Replace drain plugs.						X

MAINTENANCE INSTRUCTIONS

1. Maintenance instructions for the electric motor, speed reducer and their mounting are contained in the appendix. Refer to the following for other maintenance procedures.

2. Inspection of drives and bearings.

- 2.1 Belt drive

- (a) Check pulley alignment - If there is evidence of severe wear on pulley flanges and/or belt edges the drive is misaligned. This should be corrected immediately to prevent premature failure. Caution - Tighten setscrews in split-tapered bushing after adjustments have been made. See Table 2, Recommended Torque Application.

- (b) Check Belt Tension - Adjust pulley centers to take up accumulated slack and make the belt taut.

- 2.2 Chain drive

- (a) Check Sprocket Alignment - If premature wear is apparent on the inner surface of the roller link sidebars and/or the sides of the sprocket teeth, there could be misaligned or loose sprockets. Realign and/or tighten sprockets. See INSTALLATION INSTRUCTIONS.

- (b) Check Sprocket Tooth Wear - Excessive tooth wear will result in hook shaped teeth. When sprockets are found in this condition, they should be replaced. If new sprockets are not immediately available, the hook can be dressed off, or possibly the sprocket can be reversed to present the unworn tooth faces to the chain.

- (c) Check Chain Tension - Adjust Sprocket centers to take up accumulated slack and make both spans taut. This is particularly important at the initial 100-hour check since some slack will be apparent as a result of the seating of chain joint components.

- (d) Check appearance of oil in chain casing. Change oil if discolored. See Table 3, Recommended Lubricants for correct oil.

- (e) Check oil level. Oil level should be at or above the mark on the dipstick on the chain casing.

- 2.3 Bearings, mainshaft and drive package output (3 HP drive only).

- (a) Check alignment of the bearing blocks.

- (b) Retighten mounting bolts, see Table 2, Recommended Torque Application.

- (c) Check for damaged seals.

- (d) Remove dirt and abrasive accumulations.

- (e) Check for noise. A soft purring noise is all you should hear.

- (f) Check bearing temperature. If temperature is too high for the hand, then check with a pyrometer. Replace bearing if temperature exceeds 200°F when properly lubricated.

- (g) Check for tightness of mainshaft bearing cap bolts. Apply 390-500 in. lb. torque while shaft is rotating.

3. Replacement of mainshaft bearing cartridges.

WARNING

Make sure power is turned off before doing any maintenance to this unit.

- 3.1 Remove the bolts securing the bearing to the base and lift the mainshaft.

- 3.2 Remove the outer housing cap. Note - Do not destroy or misplace the shims under the cap. These shims are necessary to provide proper fit on the Cartridge Unit.

- 3.3 Remove the Old Cartridge Unit and coat shaft lightly with oil or grease. Slide the new Cartridge Unit on the shaft and center it in the outer housing base. Tighten the bearing to the shaft as follows:

- (a) Slip locking collar over eccentric of bearing cone.

- (b) Turn collar by hand in the direction of shaft rotation unit snug.

- (c) Tighten collar with spanner wrench.

- (d) Tighten setscrew to shaft. See Table 2, Recommended Torque Application.

- 3.4 Seat the outer housing cap, making sure that the identifying groove in the cap is on the same side as the groove in the outer housing base.

- 3.5 Lower mainshaft and tighten cap bolts "Finger Tight". If Cartridge Unit is too loose, one shim from either or both sides may be removed as is necessary to provide proper fit.

- 3.6 Check shaft again for freedom of rotation, then run the unit for 15 minutes and while running tighten the cap bolts snugly using

TYPICAL TROUBLESHOOTING GUIDE - AUTOTROL

TROUBLESHOOTING GUIDE

Roller Chain Drive		
Trouble	Probable Cause	Corrective Action
Noisy Drive	1. Moving parts rub stationary parts. 2. Chain does not fit Sprockets. 3. Loose chain. 4. Faulty lubrication. 5. Misalignment or improper assembly. 6. Worn parts.	1. Tighten and align casing and chain. Remove dirt or other interfering matter. 2. Replace with correct parts. 3. Maintain a taut chain at all times. 4. Lubricate properly. 5. Correct alignment and assembly of the drive. 6. Replace worn chain or bearings. Reverse worn sprockets before replacing.
Rapid Wear	1. Faulty lubrication. 2. Loose or misaligned parts.	1. Lubricate properly. 2. Align and tighten entire drive.
Chain Climbs Sprockets	1. Chain does not fit sprockets. 2. Worn out chain or worn sprockets. 3. Loose chain.	1. Replace chain or sprockets. 2. Replace chain. Reverse or replace sprockets. 3. Tighten.
Stiff Chain	1. Faulty lubrication. 2. Rust or corrosion. 3. Misalignment or improper assembly. 4. Worn-out chain or worn sprockets.	1. Lubricate properly. 2. Clean and lubricate. 3. Correct alignment and assembly of the drive. 4. Replace chain. Reverse or replace sprockets.
Broken Chain or Sprockets	1. Shock or overload. 2. Wrong size chain, or chain that does not fit sprockets. 3. Rust or corrosion. 4. Misalignment. 5. Interferences.	1. Avoid shock and overload or isolate through couplings. 2. Replace chain. Reverse or replace Sprockets. 3. Replace parts. Correct corrosive conditions. 4. Correct alignment. 5. Make sure no solids interfere between chain and sprocket teeth. Loosen chain if necessary for proper clearance over sprocket teeth.

STUDENT-PARTICIPANT GUIDE
for
Training Module II2FWW
Basic Rotating Biological Surface

II2FWW BASIC ROTATING BIOLOGICAL SURFACE OPERATION

STUDENT OUTLINE

Note: Participants will receive a copy of each transparency used in the presentations. Participants should own or receive WPCF Manual of Practice No.11, Operation of Wastewater Treatment Plants. Appropriate Chapters in the Manual should be studied for each topic.

I. Introduction: Wastewater Treatment Systems

- A. Review typical treatment plant flow diagrams (Trans BD-1, BD-2)
- B. Note the purpose of individual unit processes
- C. Observe typical water quality changes e.g. BOD and Susp. Solids reduction
- D. Study treatment criteria (Trans BD-3, BD-4)
 - 1. U.S.E.P.A. secondary treatment definition
 - 2. Iowa DEQ water quality criteria and purposes of the criteria
- E. Note the function of RBS units (Trans BD-5)
 - 1. Secondary treatment
 - 2. Tertiary treatment

II. Wastewater Chemistry; Sampling; Analysis

- A. Review the common water quality parameters in RBS plants. Note the meaning and significance of the parameter. Briefly review appropriate analytical techniques. (Trans BD-6, BD-7, BD-8, BD-9, BD-10 & BD-11)
- B. Distinguish between grab and composite sampling
 - 1. Need to know variations in parameters and potential impact on process
 - 2. Composite data provides an averaging effect
 - 3. Note IDEQ monitoring requirements
- C. Note available analytical references
 - 1. Standard Methods
 - 2. WPCF MOP No.18 (Simplified Methods)
 - 3. USEPA Common Methods Manual
 - 4. Appendix III WPCF MOP No.11

III. Fundamental Biological Systems

- A. Review types of biological processes (Trans BD-12)
- B. Study the growth curve and relate it to the F/M ratio concept (Trans BD-13)
- C. Study the nature of bioactivity in a fixed film system (Trans BD-13)

IV. RBS System

- A. Study the system layout and process description (Trans BD-14, BD-16, BD-19)
- B. Note the unit configurations and component parts (Trans BD-14, BD-16, BD-19)
- C. Study the factors that affect process performance
 - e.g. grit accumulation in chambers
 - grease interference
 - solids clogging
 - pH depression
 - cold temperatures - housing
 - organic levels and nitrification
- D. Observe typical systems (Slides DS-1 thru DS-17)

V. RBS Process Control and Operation (Trans BD-20, BD-21)

- A. Study typical reporting and monitoring requirements using Emmetsburg example
- B. Review the importance of pre-treatment regarding toxics, grit, grease, etc.
- C. Study operational characteristics that can be noted to evaluate performance e.g. color of bio-mass, DO change in stages, NO_3 levels in stages
- D. Study final settling tank operation
 - 1. Affect of flow variation (Trans BD-9)
 - 2. Sludge pumping vs. thickness and potential for rising sludge due to denitrification

VI. Mechanical Units and Maintenance

- A. Review components (Trans BD-17, BD-18)
- B. Note the sources of information e.g. Autotrol, WPCF Manuals of Practice, Unit Manufacturers)
- C. Study typical preventive maintenance (Trans BD-22, BD-23, BD-24)
- D. Note typical problems and remedies (Trans BD-25)

EXAMINATION QUESTIONS

Note: The order of the questions follows the topical coverage of the module.

1. Typical primary treatment removals in a domestic wastewater treatment plant are

	<u>BOD</u>	<u>Susp. Solids</u>	<u>Settleable Solids</u>
a.	60%	90%	98%
b.	35%	60%	95%
c.	15%	40%	60%

- T F 2. Grit removal decreases the amount of fixed or inorganic solids in the primary effluent.
- T F 3. It is not necessary to remove grease ahead of a RBC biological unit.
4. Which of the following wastewater treatment processes more closely works like an RBC process
- Trickling filter
 - Anaerobic digester
 - Activated sludge aeration tank
5. State the monthly average secondary treatment criteria for municipal wastewater treatment plants established by USEPA.
- _____
- _____
- _____
6. The Iowa Department of Environmental Quality establishes more stringent (lower concentrations) and additional water quality effluent requirements.

Two of the three stream water quality classifications are _____ and _____.

7. Cite two reasons for limiting ammonia nitrogen levels in treatment plant effluents
- a. _____
 - b. _____
- T F 8. Rotating biological contractors can be used to reduce carbonaceous oxygen demand and oxidize ammonia.
- T F 9. Rotating biological contactors can be used to strip phosphorus from water into the air.
10. Nitrification refers to the following change
- a. Nitrates to nitrites to ammonia
 - b. Ammonia to nitrites to nitrates
 - c. Nitrates to nitrites to nitrogen
11. Which of the following sampling techniques would be used to evaluate short term industrial waste loadings to the plant
- a. Grab
 - b. Composite
 - c. Heterotrophic
- T F 12. Alkalinity of Iowa waters is largely due to bicarbonates and it provides a source of CO_2 for nitrification.
- T F 13. The COD of wastewater samples is normally lower than the 5 day BOD.
- T F 14. Nitrification causes a higher BOD value.

15. Nitrification can occur in a BOD test in the first day if
- You heat the sample to 30°C
 - You use thiourea
 - The nitrifying population is high enough
 - If you add sulfur enzymes
16. A source of information for conducting process control tests -- other than Standard Methods is _____.
- T F 17. Composite samples should be taken proportional to flow rate and represent an averaging of the concentrations over the sampling period.
18. Aerobic biological activity would result in which of the following end products when acting upon organic material
- CH₄, CO₂
 - O₂, H₂S, N₂
 - CO₂, H₂O
 - NH₃, O₂, H₂S
- T F 19. Facultative bacteria are very common in wastewater treatment and they can work in the presence of oxygen or in the absence of oxygen.
- T F 20. Sloughing or the loss of biological solids in a RBS system is due to a high sulfate concentration in the water.
- T F 21. Nitrogen gas can be formed anaerobically by bacteria.
- T F 22. Nitrifying bacteria are slow growing bacteria that begin to develop when low organic levels are reached.

- T F 23. A RBS unit obtains oxygen from air by rotating the bio-film into the air.
24. Which of the following is the typical rotational speed of the disc.
- a. 5 rev/hr
 - b. 1 rev/min
 - c. 1 rev/sec
 - d. 50 rev/day
25. Grit and grease should be removed ahead of a RBC unit. What problems could result if they were not removed adequately?
- _____
- _____
- _____
- T F 26. Nitrifying organisms are more likely to be present in the first stage unit of a carbonaceous — nitrification unit.
- T F 27. Power consumption of RBC systems is normally significantly lower than comparable bio-treatment systems.
28. Covers over bio-disc units can serve two purposes. The purposes are
- a. _____
 - b. _____
- T F 29. Nitrifying biomass frequently appears golden-brown in visual appearance.
- T F 30. The purpose of a final settling tank in a RBC system is to return active biological organisms to the disks.

- T F 31. Bio-mass is stripped from the plastic medium as it passes through the wastewater in the submerged area of the unit.
32. The contactor shafts are rotated by _____
and the main shaft is supported by _____
- T F 33. If nitrification is occurring in your RBC system the NO_3 , nitrate, concentration will increase through the plant.
34. The typical appearance of the bio-mass for organic removal is
- a. Orange
 - b. Reddish-brown-individual cells
 - c. Gray-shaggy mass
35. Evidence of worms, protozoa or rotifers is most likely to occur
- a. In the primary effluent
 - b. In the early stages of bio-mass
 - c. In the latter stages of bio-mass
 - d. Not at all in this type of process
36. The Dissolved Oxygen concentration should normally
- a. Increase
 - b. Decrease
- as you proceed through the stages of the RBC system.
37. Excessive sloughing after the plant has operated for an extended period may be due to
- _____
- _____
38. The development of a white bio-mass could be due to
- _____

39. The approximate pH goal for good nitrification is most nearly

- a. 6.5
- b. 7.0
- c. 8.5
- d. 10.0

40. Floating sludge in final settling tanks may be due to biological _____
and can be corrected by _____
_____.